7. A continuous fractionating column is to be designed for separating 10,000 kg/hr of a liquid mixture containing 40 mole% methanol & 60 mole% water in to an overhead product containing 97 mole% methanol and a bottom product having 98 mole% water. A molar reflux ratio of 3 is used.

Calculate:

(i) Moles of overhead product obtained per hour &

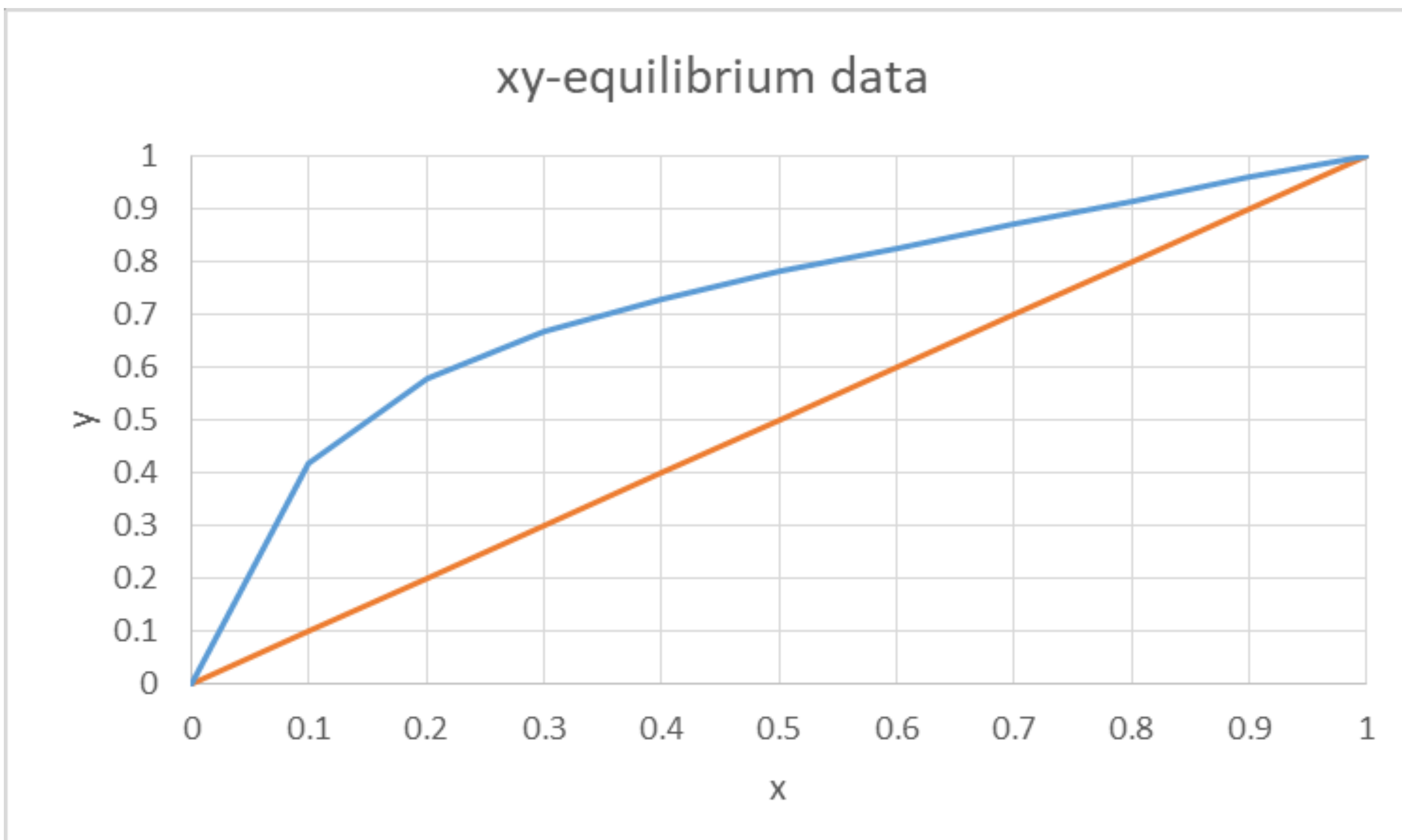
(ii) Number of ideal plates & location of the feed plate, if the feed is at its bubble point.

Equilibrium Data:

X	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Y	0.417	0.579	0.669	0.729	0.78	0.825	0.871	0.915	0.959

x= mole fraction of methanol in liquid &

y= mole fraction of methanol in vapor phase


xy-equilibrium data
y
x
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Solution:-

Feed

10,000 kg/hr

0.4 Methanol
0.6 water

Distilled

$X_D = 0.97$

Bottom

$X_B = 0.02$

given $\boxed{R = 3}$

↳ assume sat'd Liquid

$\boxed{q = 1}$ ⟵ q مش معطيني

Constant Molal flow

↳ $10000 \frac{kg\ (H_2O + Methanol)}{hr} \cdot \frac{1\ Kmol}{21.8\ kg} = 458.7$

$\overline{Mw} \Rightarrow$

$$\frac{1}{\overline{Mw}} = \frac{X_1}{Mw_1} + \frac{X_2}{Mw_2} =$$

$$\frac{1}{\overline{Mw}} = \frac{0.4}{32} + \frac{0.6}{18}$$

$$\overline{Mw} = 21.8$$

(1) Moles of overhead / hr (D)

by Material Balance:

$458.7 = D + B$ — ①

$(0.4 * 458.7) = (0.97\ D) + (0.02\ B)$

↳ Solve

$\boxed{D = 180.7}$ $\boxed{B = 278.1}$

(2) Np

operating line of the top section

$$y = \frac{R}{(R+1)} x + \frac{X_D}{(R+1)} \Rightarrow y = 0.75x + 0.2425$$

Top section operating Line:-

$y = 0.75 + 0.2425$

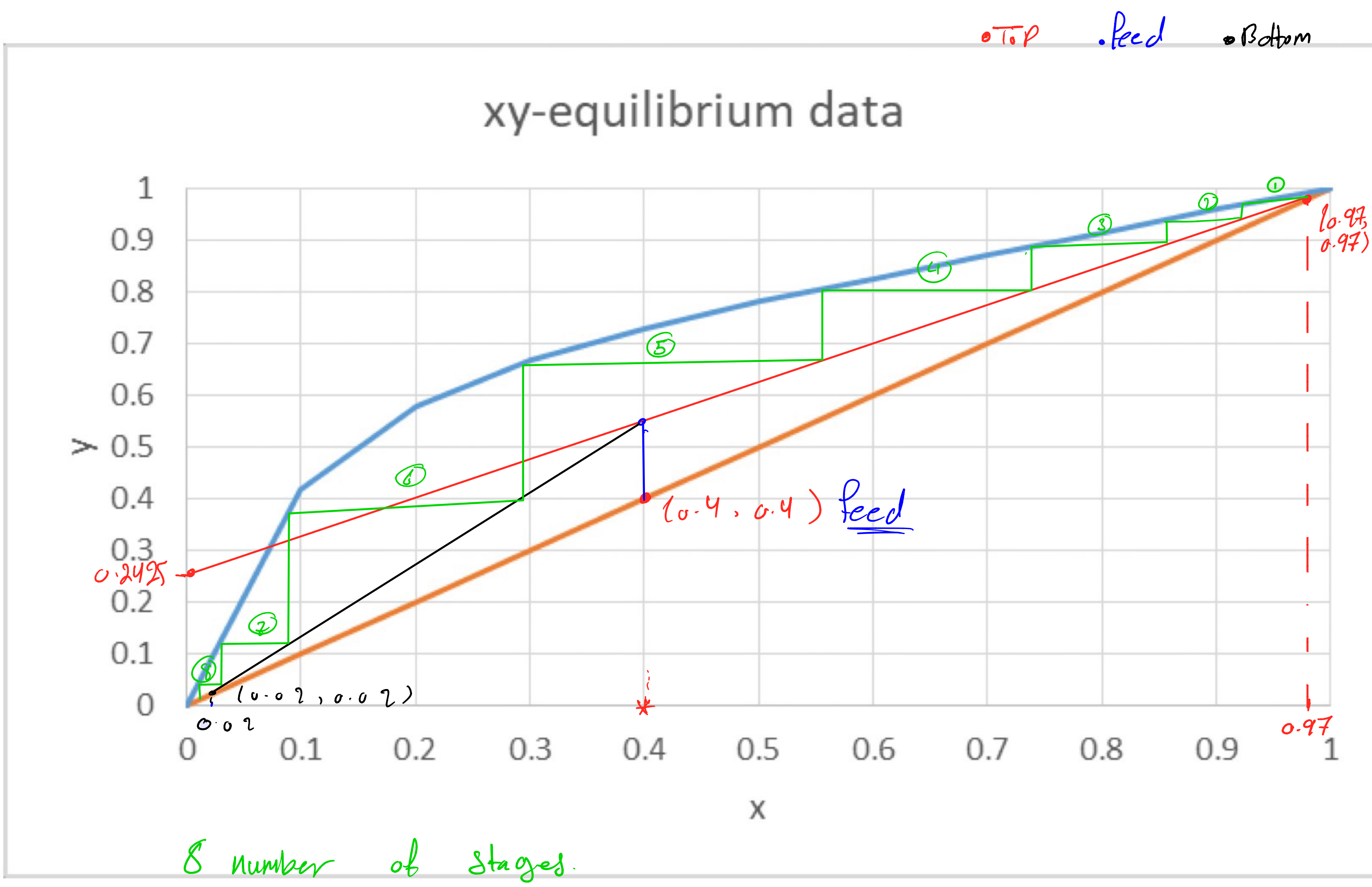
feed operating line:-

$y = \infty x + \infty$

vertical line ↵

Bottom section:-

As shown in the figure ↓



8 number of stages.